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THE EFFECTS OF SOPITE SYNDROME ON SELF-PACED AIRSICKNESS DESENSITIZATION PROGRAM

by

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September 1998

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The U. S. Navy implemented the Self-Paced Airsickness Desensitization (SPAD) program in 1989 for aviation students whose incidence of airsickness was not easily resolved. Some participants may have also experienced symptoms that are not typically recognized as motion sickness, including prolonged drowsiness and/or mood changes. These effects are part of a poorly understood response to motion termed "Sopite Syndrome." This thesis explores the effects of Sopite Syndrome on student aviators diagnosed with motion sickness. Sixty SPAD program participants completed a survey comprised of scales, which estimate motion sickness, drowsiness, fatigue, and sleep disturbances during SPAD treatment days. Results indicate: (1) symptoms consistent of Sopite Syndrome were reported by 45% of the participants and (2) the presence of Sopite Syndrome in a SPAD participant was not an accurate predictor for successful treatment and return to flight status.

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THE EFFECTS OF SOPITE SYNDROME ON SELF-PACED AIRSICKNESS DESENSITIZATION PROGRAM

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ABSTRACT

The U. S. Navy implemented the Self-Paced Airsickness Desensitization (SPAD) program in 1989 for aviation students whose incidence of airsickness was not easily resolved. Some participants may have also experienced symptoms that are not typically recognized as motion sickness, including prolonged drowsiness and/or mood changes. These effects are part of a poorly understood response to motion termed "Sopite Syndrome." This thesis explores the effects of Sopite Syndrome on student aviators diagnosed with motion sickness. Sixty SPAD program participants completed a survey comprised of scales, which estimate motion sickness, drowsiness, fatigue, and sleep disturbances during SPAD treatment days. Results indicate: (1) symptoms consistent of Sopite Syndrome were reported by 45% of the participants and (2) the presence of Sopite Syndrome in a SPAD participant was not an accurate predictor for successful treatment and return to flight status.

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EXECUTIVE SUMMARY

Airsickness is one of the problems encountered by student aviators while attempting to adapt to the foreign environment of aviation. It is considered among the most provocative forms of motion sickness (Strongin & Charlton, 1991). The incidence of airsickness in navigators has been estimated at 22%, and the associated cost includes delay of flight training, incomplete flight events, and rescheduling of flights (Royal, Jessen, & Wilkens, 1984). Additionally, such episodes with airsickness may be severe enough to interfere with control of the aircraft (Dehart, 1985). Therefore, motion sickness during flight training continues to be an expensive and difficult issue, especially in the military. The effects of airsickness on student aviators include nausea to the point of incapacitation, vomiting, degraded flight performance or premature termination of flight (NOMI, 1997).

The U. S. Navy implemented a treatment program in 1989 for aviation students whose incidence of airsickness was not easily resolved. The Self-Paced Airsickness Desensitization (SPAD) program requires a participant to adapt during a four- to six-week duration to repeated head movements in four directions during gradually increasing rates of on-center rotation. Some SPAD participants may have also experienced symptoms that are not typically recognized as motion sickness, including prolonged drowsiness and/or mood changes (Lawson & Mead, 1997). These effects are part of a poorly understood response to motion termed "Sopite Syndrome." Graybiel and Knepton (1976) defined Sopite Syndrome as extreme drowsiness, fatigue, and mood changes. Remarkably, the impact of Sopite Syndrome on military aviation is virtually unknown

(Lawson & Mead, 1997). Research has recently been initiated to explore Sopite Syndrome's effect on student aviators who participated in the SPAD program.

The purpose of this study was to determine the effects of Sopite Syndrome on student aviators diagnosed with motion sickness who participated in the SPAD program. Specifically, it assessed the presence of Sopite Syndrome symptoms in SPAD participants and their relationship with successful completion of treatment and return to flight status. Sixty SPAD participants completed a multiple scale survey intended to estimate motion experience, motion sickness, mood changes, drowsiness, fatigue, and sleep disturbances during days on which they were subjected to controlled rotation. The scales were designed to detect the various symptoms associated with Sopite Syndrome.

Exploratory analyses combined with hypothesis testing of the survey data were performed to evaluate the relationships between the different survey scales and to determine the percentage of SPAD participants who experienced increased severity in symptoms during training. The analyses reveal that all of the scales (i.e. Sleep, Motion Sickness During SPAD Training, Mood, Drowsiness During SPAD Training, and Fatigue), with the exception of motion sickness, appear to be significantly related to one another. The actual percentage of respondents who reported increases between the two conditions was 53% for the sleep scale, 98% for the motion sickness scale, 45% to 85% for each of the 16 moods that were prevalent in student aviators who were referred to the SPAD program, 87% for the drowsiness scale, 90% for the sleepiness rating scale, and 70% for the fatigue scale.

A symptomatic profile for Sopite Syndrome candidates was developed based upon the literature. From the original sample population of 60 former SPAD participants,

27 (45%) of them exhibited symptoms characteristic of Sopite Syndrome. Of these 27 individuals, 19 (70%) of them were returned to flight status. Furthermore, of the 33 remaining SPAD participants not classified as exhibiting symptoms characteristic of Sopite Syndrome, 28 (85%) were returned to flight status. The research concluded that the presence of Sopite Syndrome in a SPAD participant was not an accurate predictor for successful treatment and return to flight status.

I. INTRODUCTION

A. BACKGROUND

The Naval Aerospace Medical Research Laboratory (NAMRL) was established in 1939 at the Naval Air Station, Pensacola. Currently, NAMRL has three departments: Biomedical Systems and Standards, Spatial Orientation Systems, and Aviation and Operational Medicine. The primary responsibility of the research laboratory is to conduct research and development in aviation medicine and allied sciences to enhance the health, safety, and readiness of Navy and Marine Corps personnel in the performance of their missions. (NAMRL, 1997)

In 1989, NAMRL established as part of the Aviation and Occupational Medicine department an airsickness rehabilitation program: Self-Paced Airsickness Desensitization (SPAD) (Naval Operational Medical Institute- NOMI, 1997). The SPAD program was established for aviators who were unable to adapt quickly to the nauseogenic (that is, inducing nausea) aviation training environment. The program's protocol includes psychological desensitization with "autogenic," self-produced, biofeedback and physical desensitization in a rotating chair with continuous biofeedback monitoring. Successful completion of the program stated is the adaptation to airsickness symptoms during a spin rate of 20 rpm for 40 minutes without problems (NOMI, 1997). This is usually accomplished by spinning at 16 rpm for 10 minutes, 18 rpm for 10 minutes and then 20 rpm for 40 minutes. For those aviators who attend the SPAD program, there is a 68% success rate for returning to flight status (Gallagher, Hopkins, Moore, & Valbracht, 1997).

It is possible that SPAD participants also experience symptoms that are not often recognized as motion sickness. This includes prolonged drowsiness and/or mood changes. Lawson and Mead (1997) state that these effects are part of a poorly understood manifestation of motion sickness known as "Sopite Syndrome." Sopite Syndrome derives its name from the Latin "sopire" which means to put to sleep (Woolf, 1981). Graybiel and Knepton (1976) formally named the syndrome upon accumulating sufficient scientific and clinical evidence through research in NAMRL's slow rotation room. The primary Sopite Syndrome symptoms are extreme drowsiness, fatigue, mood changes, disinclination to work, apathy, irritability, mental depression, sleep disturbances, and difficulty concentrating (Graybiel & Knepton, 1976; Graybiel, Kennedy, Knoblock, Guedry, Mertz, McCleod, Colehour, Miller, & Fregly, 1965). Sopite Syndrome may occur during or after flight, and can exist in isolation from more apparent symptoms of "regular" motion sickness such as nausea and vomiting (Lawson & Mead, 1997). Furthermore, Lawson and Mead (1997) state it can last long after nausea has disappeared and can debilitate some individuals. The syndrome can be extremely hazardous in military operations where sleep deprivation and other performance challenges may exist.

Sopite Syndrome may have as much impact on military aviation flight performance as the more commonly recognized symptoms of motion sickness (Lawson & Mead, 1997). Lawson and Mead (1997) contend that as the Navy prepares for the future, research into this motion-related syndrome will be of key importance to aerospace training and operations. The focus of this thesis is to determine the incidence and effects of Sopite Syndrome on individuals diagnosed with "regular" motion sickness who participated in the SPAD rehabilitation program. Additionally, it will explore the

association of Sopite Syndrome with the successful completion of SPAD treatment by student aviators and ultimate return to flight status.

B. PURPOSE

The purpose of this thesis is to investigate the responses to a survey and determine if personnel diagnosed with motion sickness exhibit symptoms characteristic of Sopite Syndrome.

C. PROBLEM STATEMENT

Airsickness continues to be a significant issue for student aviators. NOMI (1997) states the cost of airsickness includes delay in flight training, rescheduling of flights, incomplete flight events, and the potential loss of situational awareness and in-flight performance degradation. The U.S. Navy's SPAD program desensitizes aviation students who have demonstrated difficulty adapting to the motional environment experienced in aircraft. However, this desensitization is limited to motion sickness symptoms (i.e., nausea, vomiting, etc.). Therefore, Sopite Syndrome symptoms potentially remain untreated in student aviators who participate in the SPAD program. The existence and impact of Sopite Syndrome on this population of student aviators is unknown.

The possible existence of Sopite Syndrome in student aviators who participated in the SPAD program makes it worthy of increased attention. An assessment of the incidence and magnitude of Sopite symptoms including an estimate of predisposing factors can be made in this specific training environment. Furthermore, due to the potential hazard of Sopite Syndrome in Naval aviation, an analysis of the survey data must be undertaken. This thesis investigated the following research questions:

1. What are the central tendencies and dispersions of the respective survey scale (i.e. Sleep, Motion Sickness During SPAD Training, Mood, Drowsiness during SPAD Training, and Fatigue) responses? Additionally, are the paired differences between the "During SPAD" and "In General" response values statistically significant for each of the survey scales?

2. Which of the original 49 moods in the Mood scale are most prevalent in student aviators who were referred to the SPAD rehabilitation program?

3. What are the relationships that exist between the respective survey scales and are these relationships statistically significant?

4. What percentage of student aviators who participated in the SPAD rehabilitation program exhibited symptoms characteristic of Sopite Syndrome? Furthermore, what percentage of Sopite candidates were subsequently either returned or not returned to flight status upon completion of the SPAD rehabilitation program?

5. Are the paired difference scores between the Sopite and Non-Sopite candidates statistically significant for each of the respective survey scales?

6. Which of the Sleep and Fatigue scale questions are most indicative of Sopite Syndrome candidates?

D. SCOPE AND LIMITATIONS

The surveys analyzed in this study are limited to the 60 completed surveys that were returned by previous participants in the SPAD program. All of the subjects had been previously diagnosed with motion sickness, so a comparison of the results with other populations is not possible. The survey was designed and administered by NAMRL researchers.

II. LITERATURE REVIEW

A. OVERVIEW

In researching literature for this thesis, insight and direction has been provided by scientists located at NOMI and NAMRL at NAS Pensacola. Various resources included civilian and government on-line medical services, Naval library assets (i.e., journals, records and etc.), and motion sickness periodicals and publications. The scope of the subject matter included the annals of motion sickness symptomatology, preventive antidotes and medications, and debilitating effects and hazards imposed on personnel in various fields of transportation. The extent of the research focused on a response to motion known as Sopite Syndrome. Primary interest was focused on the effects of Sopite Syndrome on humans and its distinction from that of "regular" motion sickness.

B. MOTION SICKNESS

Motion sickness is a chronic disease endured on highways, at sea, in the air, and in space. The most readily perceived and easily recognized characteristics of motion sickness are nausea, vomiting, drowsiness, pallor, cold sweating and/or loss of appetite (Jozsvai & Pigeau, 1996). Specific symptoms that occur during unaccustomed motion will depend upon on exposure conditions and the individual (DiZio & Lackner, 1992). A wide variety of motions qualify as offensive; thus there are many names for motion sickness, including carsickness, seasickness, train sickness, flight simulator sickness, motion-picture sickness, and airsickness.

Airsickness is considered among the most provocative forms of motion sickness (Strongin & Charlton, 1991). Flight in turbulent air with frequent sudden and

unanticipated changes in direction with little reference to spatial orientation is good reason. Technological improvements in modern combat aircraft have dramatically increased the probability that military aircrew will be exposed to these conditions for extended periods. The novice aviator is inclined to have a higher frequency of airsickness than the experienced aviator (Dobie, 1974). Therefore, motion sickness during flight training continues to be an expensive and difficult issue, especially in the military. The effects of airsickness on student aviators include nausea to the point of incapacitation, vomiting, degraded flight performance or premature termination of flight (NOMI, 1997).

Military experience with airsickness in World War II provided some interesting statistics:

> ... it was learned that 10 to 11 percent of all flying students became air sick during their first 10 flights, and that 1 to 2 percent of them were eliminated from flying training for that reason. Other aircrew members in training had even greater difficulty and the air sickness rate among them ran as high as 50 percent in some cases. It was found that only fully trained combat crews, other than pilots, sometimes became airsick which affected their combat efficiency (Dehart, 1985, p. 372).

In more recent studies the incidence of airsickness in United States military flight training reveal that approximately 11% to 38% of student aviators become airsick, dependent upon aircraft type and the stage of training (Jones, Levy, Gardner, & Patterson, 1985; Rubin, 1942). The incidence of airsickness in navigators has been estimated at 22%, and the associated cost includes delay of flight training, incomplete flight events, and rescheduling of flights (Royal, Jessen, & Wilkens, 1984). Additionally, such episodes with airsickness may be severe enough to interfere with control of the aircraft (Dehart, 1985).

C. AIRSICKNESS REHABILITATION PROGRAMS

Bagshaw and Stott (1985) state that an essential trait of motion environments that give rise to motion sickness is that they produce patterns of sensory input that are in conflict with those based on past motion experience. Spontaneous adaptation to the provocative motion in the flight environment commonly resolves the problem of airsickness for student aviators (Banks, Salisbury, & Ceresia, 1992). However, for a relatively small proportion of subjects, due to high susceptibility or a slow adaptive response, motion sickness continues (Bagshaw & Stott, 1985). Such conditions impair ability and erode confidence in those afflicted. The result is poor performance in training and the increased likelihood of being removed from flight status. Bagshaw and Stott (1985) state the designation of a student with continuing motion sickness problems can only occur after a reasonable period has been allowed for spontaneous adaptation. Furthermore, motion sickness susceptibility is not an indicator of a student aviator's ability at the airborne task; motion-sick aviators once treated have gone on to be outstanding pilots and navigators.

In some individuals, incidence of airsickness may be reduced by the use of prophylactic drugs during the early stages of training. The Royal Air Force (RAF) commonly uses 0.3 – 0.6 mg of hyoscine hydrobromide (Scopolamine USP), although cinnarizine 15 – 30 mg has been found useful for flights of long duration (Bagshaw & Stott, 1985). For student aviators in the RAF use of such drugs is prohibited for solo flying. In the Canadian Forces (CF), airsickness is a significant obstacle in the training of some student aviators (Banks et al., 1992). In conventional therapy, when organic pathology is ruled out, and no contraindications exist, anti-emetic medication is

prescribed to subdue symptoms for a maximum of three dual–only flights (Banks et al., 1992). An effective procedure with acceptable side-effects is the combining 25 mg of phenrgan with 30 mg of ephedrine 60 to 90 minutes prior to flight. In the case of both the Royal and Canadian Air Forces, if student aviators become airsick to the point of vomiting while on medication, or during subsequent flights, the student may be grounded and considered for rehabilitation (Bagshaw & Stott, 1985; Banks et al., 1992).

An overview of the RAF and CF Airsickness Rehabilitation Programs showed marked similarities in subject identification and selection procedures. The rehabilitation phase did vary in structure and content for the two countries. Banks, Salisbury, and Ceresia (1992) outline the CF rehabilitation as being based on a three-phase treatment program as follows:

1. Phase One, consisting of biofeedback relaxation therapy;
2. Phase Two, consisting of ground-based desensitization therapy; and
3. Phase Three, consisting of in-flight desensitization therapy.

The RAF differed in design in that biofeedback relaxation therapy was not incorporated and in the use of a high performance aircraft, the Hunter T7, for the in-flight phase of desensitization (Bagshaw & Stott, 1992). Bagshaw and Stott (1992) state that in earlier years of desensitization treatment it was considered important that no attempt should be made to carry out maneuvers beyond the range of the training syllabus. This idea has been set aside with the use of the Hunter T7 aircraft for rehabilitation flying. The student aviator now progresses as far as capable, both in terms of provocative aircraft maneuver that can be tolerated and building confidence to meet the demands of flying a high performance aircraft. Upon successfully adapting to this aircraft the student aviator does

not need to restrict his or her aspirations, nor the expectations of the assigned instructor, nor his or her career to flying in a less provocative environment such as in helicopters and transport aircraft.

D. SELF-PACED AIRSICKNESS DESENSITIZATION PROGRAM

If a student aviator in the United States Navy is unable to adapt to the aviation cockpit after two or three flights due to airsickness and also has not shown a significant reduction in symptoms by the end of these flights, he or she is unlikely to resolve the issue spontaneously. Early treatment is indicated and a referral to the squadron's flight surgeon is in order. At this point an aeromedical evaluation is performed on the student to rule out medical causes of vomiting. Additionally, the flight surgeon will address the student's motivation, performance, and interaction within the squadron and talk over the patient's situation with the flight instructors involved in his or her training. If a specialist consultation is not required, the flight surgeon will diagnose the airsickness as due to poor adaptation. Prior to returning to the squadron and getting back into the cockpit, each airsick-prone student is given information on airsickness that discusses associated signs and symptoms. Additionally, information on airsickness countermeasures to decrease susceptibility and techniques to help adjust to the flight environment are provided. (NOMI, 1997)

Upon the flight surgeon's approval, airsick-prone students are then given an opportunity to try antiemetic medications for the next three flights to see if they are then able to adapt to motion in the cockpit (NOMI, 1997). The medication prescribed is phenergan 25 mg with ephedrine 25 mg taken 60 minutes prior to flight. Scopolmaine, meclizine, and dramamine are not recommended at present. For those airsick-prone

students who do not make progress in adapting to the aviation environment in the next three subsequent flights, referral to NOMI for further evaluation is in order. Allowed responses in the cockpit by a student following medication treatment is complete self-control of, or minimal, symptoms, not to include vomiting or cognitive variations that would result in reduced flight performance or hasty termination of a mission (NOMI, 1997). Automatic referral is imposed on students who are incapacitated or affected by reoccurring vomiting episodes after one or two flights while on medication.

Internal Medicine and Psychiatry are identified in NOMI (1997) as the primary departments responsible for the administration and conduct of the motion sickness desensitization program. However, when required NOMI will refer students to ENT, Opthalmology and Neurology. NOMI will schedule initial neurologic and vestibular evaluations, followed by a psychological interview including the Minnesota Multiphasic Personality Inventory and family history. Once the evaluation is completed and further appraisal is not necessary, the student is deemed appropriate to begin treatment in the Navy's airsickness rehabilitation program.

Psychologists in the Psychiatry Department are responsible for conducting the biofeedback training. The program is divided into ten one-hour sessions conducted twice daily for five days. Initially, the airsick-prone student becomes acquainted with biofeedback theory and its relevance in the treatment of airsickness. Additionally, advice is given to avoid particular foods, including milk, chocolate, MSG and alcohol. The airsick-prone student is then instructed to schedule a vigorous one-hour physical workout daily. Desensitization therapy will immediately follow at the conclusion of biofeedback

training. Desensitization has proven to be a valid clinical tool in treatment of airsickness (Banks et al., 1992).

The SPAD rotational-chair desensitization process consists of using progressive increases of severity in cross-coupled stimulation under a self-paced schedule. The airsick-prone student is seated on a rotating chair and secured in place by a qualified technician. The individual is then rotated while conducting a series of head tilts, changing head position every ten seconds. Each student is scheduled a one-hour session in the morning and a one-hour session in the afternoon separated by a three-hour break. The rate and direction of spin is alternated for each session, and the airsick-prone student is encouraged to build up tolerance at each speed level to form progressive increases to his or her degree of tolerance. Initial speed of rotation is set at four rpm and increased or decreased in two-rpm increments. Sessions are aborted if the student becomes nauseated, vomits or is otherwise incapacitated. An individual is considered proficient and returned to flight status upon attainment of a spin rate of 20 rpm for 40 minutes without any difficulties or problems. The average time amongst SPAD participants to obtain proficiency is 45 to 60 days. (NOMI, 1997)

It is known the SPAD program can help student aviators adapt to symptoms of motion sickness, such as nausea. In addition, students participating in the SPAD program may also feel symptoms that are not often recognized as motion sickness, including prolonged drowsiness or mood changes. These effects are part of the related Sopite Syndrome.

E. SOPITE SYNDROME

It is common knowledge that motion can cause drowsiness (e.g. rocking a baby to sleep), but it was not until 1976 at NAMRL, NAS Pensacola, that Graybiel and Knepton explicitly identified the "Sopite Syndrome" as a "sometimes sole manifestation of motion sickness" (Graybiel & Knepton, 1976). As stated earlier, typical characteristics or symptoms of the syndrome in addition to drowsiness are chronic fatigue, yawning, the disinclination to perform work, either physical or mental, and the lack of desire to participate in group activities (Graybiel & Knepton, 1976). This evidence had been gathered in large part from thorough and methodical observations in connections with experiments conducted in slow rotation rooms at NAMRL. Additionally, the scientists noticed different forms or types of related symptoms such as irritability, daydreaming, difficulty in concentrating, sleep interruptions, lack of interest or concern, increased laziness, and frequent napping (Lawson & Mead, 1997).

One of the significant symptoms in the diagnostic criteria of motion sickness is drowsiness. In addition to drowsiness, other cardinal symptoms are vomiting, nausea, change in skin color, cold sweating, and increased salvation (Miller & Graybiel, 1974; Graybiel, Wood, Miller, & Cramer, 1968). These results indicate that the diagnostic symptoms of a specific case of Sopite Syndrome are distinctive and separate from that of motion sickness except for the common trait of drowsiness.

Generally, the symptoms characteristic of Sopite Syndrome are blended together with different symptoms but under two circumstances the Sopite Syndrome constitutes the main or sole process open to view and readily perceived in respect to motion sickness (Graybiel & Knepton, 1976). One such circumstance is identified as the point at which

the magnitude of the eliciting stimuli is at or approaching an individual's susceptibility; at this point the syndrome is evoked in the presence or absence of other motion sickness symptoms (Lawson & Mead, 1997). Therefore, Sopite Syndrome can be present in the absence of more apparent symptoms of motion sickness such as nausea and vomiting (Graybiel et al., 1968; Miller & Graybiel, 1974). The second circumstance takes place during the course of prolonged exposure in a motion environment and at some point the individual adapts to the environment resulting in the sudden or gradual disappearance of motion sickness symptoms, except for reactions characteristic of Sopite Syndrome (Lawson & Mead, 1997). Therefore, Lawson and Mead (1997) explain that Sopite Syndrome characteristics can last long after nausea and vomiting have subsided and can be debilitating to some individuals.

The above was noticed in 1965, when four aviators were exposed to a rotating environment for a period of twelve days (Graybiel et al., 1965). Lawson and Mead (1997) state the candidates chosen were two Navy and two Marine Corps officers who had completed the acrobatic stage of flight training. Each was highly motivated and instructed in the importance of the experiment on the space effort. Additional selection factors consisted of good general fitness and mental discipline and a history of less than average susceptibility to motion sickness. However, even after adapting to nauseating stimuli each of the four showed signs of Sopite Syndrome including an episode in which one Marine Corps officer fell asleep on watch (Graybiel et al., 1965). Therefore, besides the difference in symptoms, Sopite Syndrome appears to occur at different periods in time in respect to the development and persistence of motion sickness (Lawson & Mead, 1997).

Graybiel and Kneapton discovered the fact that the time course of Sopite Syndrome differs somewhat from that of the general symptomology of motion sickness. Therefore, instances of Sopite Syndrome symptoms can occur either before or after the disappearance of typical symptoms of motion sickness. This apparent difference in the time course of symptoms provides further evidence that the existence of Sopite Syndrome is a separate distinct identity to that defined by the cardinal symptoms of motion sickness.

Regular motion sickness usually consists of nausea, vomiting, cold sweating, increased salvation, flushing/warmth, pallor, headache, and dizziness. During a participant's SPAD session such effects will usually arise while conducting head movements and then start to subside promptly upon completion of a SPAD session. In addition to the symptoms identified above, participants frequently report drowsiness. Researchers credit these feelings of drowsiness in some degree as part of Sopite Syndrome (Graybiel & Knepton, 1976).

Lawson and Mead (1997) state that the most prominent symptom of Sopite Syndrome is uncharacteristic episodes of drowsiness, in particular when the unusual motion has just ceased. These episodes include drowsiness at unusual times; more frequent episodes of drowsiness than usual; drowsiness at the normal time(s), but stronger than usual; frequent yawning; having to fight to keep from falling asleep; lethargy; stupor; inattentiveness or loss of ability to concentrate; daydreaming; needing to take a nap (if that is not normal for an individual); and going to bed earlier (or waking up later) than normal (Clark, 1996).

In addition to drowsiness, certain mood changes might take place with the Sopite Syndrome. Comprising these mood changes are disinclination to work; desire to be left

alone (not wanting to participate in group activities); complaining; emotional depression; apathy; lethargy; melancholy; and irritability (Lawson & Mead, 1997). These mood changes may occur to a participant during a SPAD session. However, such shifts in mood are thought to be more frequent and noticeable some time subsequently following a SPAD session (Clark, 1996).

It is clear from the evidence presented that Sopite Syndrome is actually capable of developing into a significant source of danger. Unfortunately, in the past twenty years, Sopite Syndrome has rarely received formal recognition (Mead & Lawson, 1997). Therefore, the potential impact of Sopite Syndrome in the fields of transportation, specifically civilian and military aviation, is not generally recognized. Lawson and Mead (1997) explain that the key components of drowsiness and mood shifts can pose a high threat to individuals who perform in such activities and others who depend on them. These factors may have profound implications on military crew coordination and could threaten mission objectives.

F. SURVEY METHODOLOGY

In the past few decades, surveys have been used extensively in resolving a particular person's past experiences to motion sickness (Kennedy, 1975; Lentz & Collins, 1977; Strongin & Charlton, 1991; Golding, Phil, & Strott, 1995). The fundamental components in the majority of the studies are extremely similar. An inquiry into each participant's frequency and level of severity with respect to motion sickness and its cardinal symptoms is quite prevalent. Furthermore, the various modes of transportation that elicit motion sickness are commonly queried. Such data is then analyzed to provide a taxonomy as to the participant's susceptibility.

A primary advantage in conducting a survey is that the researchers can sample motion sickness experience over a wide range of provoking conditions without having to expose participants to actual stimuli (Reason & Brand, 1975). Fowler (1993) discusses various considerations in choosing a method of data collection. Group- administered surveys are commonly used in motion sickness studies because they are quick to administer and score, and overall participants do not have difficulty recalling motion sickness experiences. Furthermore, participants do not resist from partaking in such studies since motion sickness is not a potentially sensitive subject such as, for example, alcohol use and family planning techniques. Above all, Reason and Brand (1975) state that the reliability and validity of motion sickness surveys have been established in many studies.

Motion sickness surveys do have drawbacks in their means of assessment. Participants may not always answer questions correctly for fear of being rejected or to avoid adverse treatment. Applicants for flight training meet this profile. However, Reason and Brand (1975) comment that student aviators are more liable to tell the truth when participating in a motion sickness survey than experienced aviators. A significant problem with surveys is that they are unable to measure an individual's motion sickness with a fine degree of accuracy. Reason and Brand (1975) indicate a potential for error is that an individual's susceptibility score (based on how often episodes occurred in the past) is inclined to reflect the individual's travel experience as well as susceptibility. For example, an individual who travels frequently and on various modes of transportation is likely to report a higher incidence of motion sickness than an individual who hardly

travels at all with few means of transportation. Survey design or appropriate weighting of scores can overcome such errors.

G. SUMMARY

Although little information existed in literature review to specifically address the research questions, a simple diagnostic criterion to determine selection of SPAD participants into Sopite and Non-Sopite group membership was developed. The primary symptoms used to develop the diagnostic criterion originated from the slow- rotation room studies conducted at NAMRL in Pensacola, FL. These symptoms include, but are not limited to: drowsiness, chronic fatigue, yawning, the disinclination to perform work, and the lack of desire to participate in group activities (Graybiel & Knepton, 1976).

Studies further indicated that the diagnostic symptoms of Sopite Syndrome are distinctive and separate from that of motion sickness (Miller & Graybiel, 1974). Additionally, Sopite Syndrome appears to occur at different periods in time when compared to the development and persistence of motion sickness (Lawson & Mead, 1997). These findings provided the perception necessary to address the questions concerning descriptive statistics and correlations between scales. Recent studies have been devoted to the etiology of Sopite Syndrome to further refine the symptomology and identification process (NAMRL, 1996). Therefore, the current research being conducted by NAMRL has special significance for military aviation.

III. DATA AND METHODOLOGY

A. DATA COLLECTION

1. Subjects

The study consisted of 60 Naval aviators who participated in the SPAD program within the last six years. The average age was 28.3 years (standard deviation = 2.6 years), ranging from 23-34 years. All subjects were asked to participate anonymously in the study regarding their SPAD experience. The participants had previously been referred to the SPAD program for motion sickness treatment.

2. Instrument

The SPAD survey consisted of seven individual scales, each focusing on a distinct element: Background and Habits, Sleep, Motion Sickness during SPAD Training, Mood, Drowsiness during SPAD Training, Fatigue, and Motion Experience. The scales are defined as follows:

(1) The Background and Habits scale requested information on whether the respondents were officially returned to flight status after SPAD training and their current duty assignments. This scale also requested the respondents to compare their normal consumption of alcohol, nicotine, caffeine, and prescription or non-prescription drugs during SPAD training to their usual or customary amounts.

(2) The Sleep scale requested that the respondents note which statements regarding sleep were true, both during SPAD (at their most challenging SPAD day) and in general (everyday life outside the SPAD experience).

(3) The Motion Sickness during SPAD Training scale consisted of two parts. For the first, the respondents were asked to estimate the amount of motion sickness

experienced during SPAD and the amount experienced during a typical day in "normal" life. These experiences were rated on a visual analog scale ranging from zero (none) to 100 (extreme). The second part was a motion sickness symptom checklist to be completed for the time during SPAD and in general. The severity of the symptoms were evaluated by the respondents on a 4-point rating scale: none = 0, minimal = 1, minor = 2, and major = 3.

(4) The Mood scale consisted of a list of words describing feelings or moods. For each word the respondents were requested to rate their typical feelings both during SPAD training and in general. These responses were evaluated utilizing a 4-point rating scale: "vv" = definitely feel, "v" = feel slightly, "?" = cannot decide, and "no" = definitely do not feel.

(5) The Drowsiness during SPAD Training scale consisted of two parts. For the first, the respondents were asked to estimate the amount of sleepiness and lowered arousal levels typically experienced during SPAD and the amount typically experienced during everyday life. These experiences were rated on a visual analog scale ranging from zero (none) to 100 (extreme). The second part was a sleepiness rating for which the respondent was requested to rate their typical level of alertness during SPAD and in general. The responses were evaluated on a 1 to 7 sleepiness scale (1 = feeling active and vital, alert, wide awake; 2 = functioning at high level, but not at peak, able to concentrate; 3 = relaxed, awake, not at full alertness, responsive; 4 = a little foggy, not at peak, let down; 5 = fogginess, beginning to lose interest in remaining awake, slowed down; 6 = sleepiness, prefer to be lying down, fighting sleep, woozy; and 7 = almost in reverie, sleep onset soon, lost struggle to remain awake).

(6) The Fatigue scale requested that the respondents note which statements regarding fatigue were true, for their experiences both during SPAD and in general.

(7) The Motion Experience scale consisted of a list of various motions; the respondent was requested to estimate the number of times they had experienced each of them since the age of twelve. The number of experiences were broken down into 4 frequency categories: 1 to 10; 10 to 20; 20 to 30; and greater than 30. The respondent was also requested to describe how often they vomited, felt nausea, or felt drowsy during or after each motion. These frequencies were measured in five categories: "never" = less than 5% of the time; "rarely" = 5% to 34% of the time; "seldom" = 35% to 64% of the time; "frequently" = 65% to 95% of the time; and "always" = greater than 95% of the time.

3. Procedure

In order to eliminate any effect of order of presentation, the seven scales for each of the surveys were placed together at random. This was accomplished by generating random numbers to represent each of the respective parts, and from these numbers the individual surveys had the scales permutated. Each survey was assigned a subject number to allow for confidentiality. The surveys were mailed in October 1996 to 136 Naval aviators who had participated in the SPAD program within the last six years. Each survey package contained a self-addressed, stamped envelope and a set of instruction. Of the 136 surveys mailed out, 60 (44%) of them were returned unsigned by mail to NAMRL.

B. DATA ANALYSIS

1. Data Tabulation

The SPAD survey responses were entered into an Excel spreadsheet. The code used to enter the data was specific to each type of scale. A Quality Assurance process to ensure accurate data entry was conducted with a three- percent error. The code for each scale was as follows:

(1) Background and Habits scale responses were recorded in the following manner: either a 1 or 0 was recorded corresponding to male or female. For the question regarding the participant's return to flight status, either a 1 or 0 was recorded for a response of "Yes" or "No" respectively. With regard to the usual amount of alcohol consumed in a typical week during SPAD training, a 1 was recorded for a response of less than 1 drink/week, a 2 for 1 to 3 drinks, a 3 for 4 to 7 drinks, a 4 for 8 to 12 drinks, and a 5 for greater than or equal to 13 drinks. The question regarding nicotine usage in a typical day during SPAD training was recorded as follows: a 1 was recorded for a response of less than 1 dose/day, a 2 for 1 to 10 doses, a 3 for 11 to 20 doses, a 4 for 21 to 30 doses, and a 5 for greater than or equal to 30 doses. For caffeine usage during a typical day during SPAD training a 1 was recorded for a response of less than 1 serving per day, a 2 for 1 to 2 servings, a 3 for 3 to 4 servings, a 4 for 5 to 6 servings, and a 5 for greater than or equal to 7 servings. The responses provided regarding any prescription or non-prescription drug usage were recorded as provided. For each of the above questions, when asked to compare the responses with their usual or customary amounts, the corresponding values of 1, 2, 3, 4, or 5 were recorded for each response provided.

(2) Sleep scale responses were recorded as follows: for each statement both during SPAD and in general, either a 1 or 0 was recorded corresponding to each response of "Yes" or "No" respectively.

(3) Motion Sickness during SPAD training scale responses were marked, and a ruler was utilized to record the corresponding value from the visual analog scale (0 – 100 mm). For the second part, the corresponding value of 0, 1, 2, or 3 was recorded.

(4) Mood scale responses for each of the words were recorded as either a 1, 2, 3, or 4, which correspond to "vv", "v", "?", and "no" respectively (see A.2.4).

(5) Drowsiness during SPAD training scale responses were marked; a ruler was utilized to record the corresponding value from the visual analog scale (0 – 100 mm). For the second part, the corresponding value of 1 to 7 was recorded.

(6) Fatigue scale responses were recorded as follows: for each statement both during SPAD and in general, either a 1 or 0 was recorded corresponding to each response of "Yes" or "No" respectively.

(7) Motion Experience scale responses were recorded as follows: the number of experiences were recorded as a 1, 2, 3, 4, or 5 corresponding to "none," 1-10, 10-20, 20-30, and greater than 30. The frequency of vomit, nausea, and drowsiness were recorded as either a 1, 2, 3, 4, or 5 corresponding to a response of either "never," "rarely," "seldom," "frequently," or "always" respectively.

2. Statistical Analysis

The study of the existence of Sopite Syndrome starts with exploratory analysis of the survey scales and the relationships that may exist between the respective scales. The exploratory analysis is performed through the use of descriptive statistics, which describe

the data in terms of measures of central tendencies and dispersions. The measures for central tendencies utilized are the mean, for the added values and/or numerical data, and the mode, for the ordinal data. The measures of dispersion or spread utilized are the standard deviation and the inter-quartile range (IQR). Graphical presentations of the distribution of the paired differences between the two conditions, "During SPAD" and "In General," for each scale are also provided through the use of histograms.

The Wilcoxon Signed-Rank Test is conducted to test whether the two conditions listed above are different. This non-parametric test is performed for each of the survey scales separately, allowing for comparison between the two conditions. The Spearman rank correlation, or Spearman's rho, is utilized to describe the relationship between any two of the respective scales. A test statistic associated with this non-parametric statistic is performed for each possible combination of scales.

Permutation tests are utilized to help substantiate group compositions into Sopite/Non-Sopite candidates. The Fisher test is conducted to test whether a relationship exists between Sopite/Non-Sopite classification and flight status. The Mann-Whitney test is conducted to test whether the two groups, Sopite and Non-Sopite, come from the same distribution. This non-parametric test is performed for each survey scale separately, allowing for comparisons between the groups.

IV. RESULTS

A. DESCRIPTIVE STATISTICS

This section provides the detailed descriptive statistics for the Sleep, Motion Sickness during SPAD Training, Mood, Drowsiness during SPAD Training, and Fatigue scales. These statistics are utilized to determine the central tendencies and dispersion of the responses provided for each of the respective scales. Since these scales pertain to behavioral data, all of the comparisons are made using the paired differences between the two conditions, "During SPAD" and "In General." Further we utilize the Wilcoxon Signed-Rank Test applied to the paired differences. This is a two-sided test. Hence, the null hypothesis (H_o) to be tested was defined as follows: no difference exists between the "During SPAD" and "In General" responses.

1. Sleep Scale

The sleep scale responses for each statement were recorded for both "During SPAD" and "In General." From this data, the total number of affirmative responses in each of the categories was tabulated for each respondent. These totals were utilized to calculate the paired differences between the total number of affirmative responses provided both "During SPAD" and "In General" for each of the respondents. The mean, standard deviation, and the first and third quartiles for these paired differences are summarized in Table 4.1. Note that there were more sleep disturbances reported "During SPAD" than "In General." The actual number of respondents who report an increase in sleep disturbances during SPAD training was 32 out of 60 (53%). Using an alpha level of 0.05, the increase in sleep disturbance was statistically significant ($Z = 2.25$, $p = 0.02$).

Response	Mean Number of Responses	Standard Deviation	1st Quartile	3rd Quartile
During SPAD	6.45	4.55	3	9
In General	5.35	4.44	2	8
Difference	1.10	3.73	-1	3

Table 4.1 Sleep Scale Responses.

The IQR is the distance between the first and third quartile and, by spanning the middle 50% of the data, it measures the spread or width of the distribution of data. As depicted in Table 4.1, the first quartile for the paired difference scores is Q1 = -1 and the third quartile for the paired difference scores is Q3 = 3, thus the IQR = 4. To help illustrate the distribution of the change in scores between the "During SPAD" and "In General" conditions for each respondent, a histogram is provided in Figure 4.1.

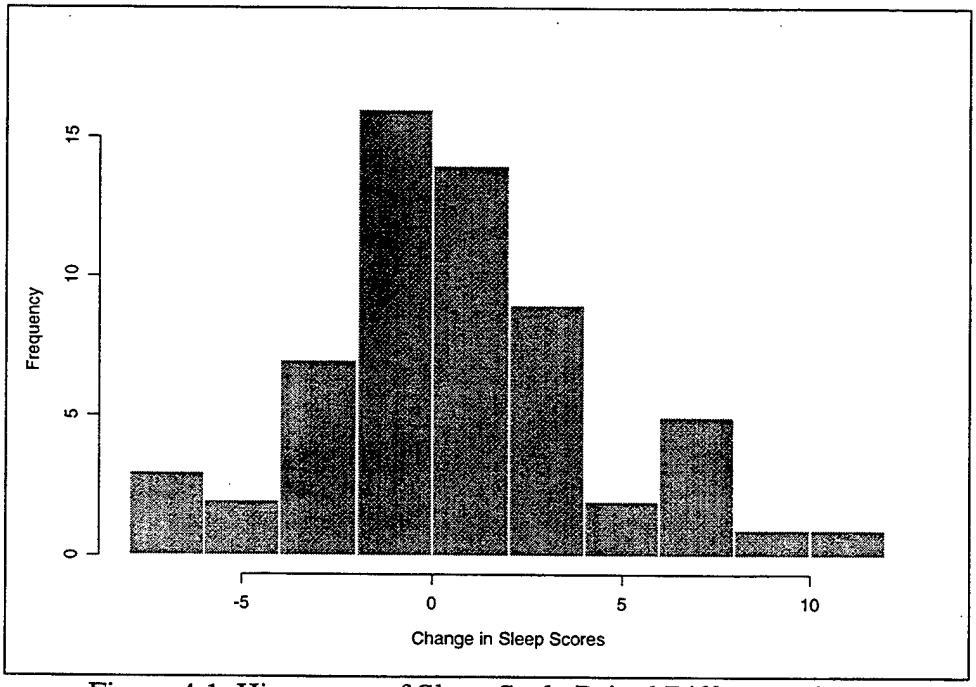

Figure 4.1 Histogram of Sleep Scale Paired Difference Scores.

2. Motion Sickness during SPAD Training Scale

The first part of the motion sickness scale consisted of a visual analog scale in which the respondents estimated the amount of motion sickness experienced "During SPAD" and the amount experienced "In General." From these two responses, the differences in the amount of motion sickness experienced by each of the respondents were calculated. These paired differences were then used to compute the mean, standard deviation, and the first and third quartiles. The results are summarized in Table 4.2. Note that the mean response for the amount of motion sickness experienced "During SPAD" was much greater than that of "In General." The actual number of respondents who reported an increase in the severity of motion sickness experienced during SPAD training was 59 out of 60 (98%). With an alpha level of 0.05, the increase in severity of motion sickness experienced was statistically significant ($Z = 6.68$, $p = 0.00$). The changes in the motion sickness scores between the two conditions, as reported by each of the respondents, are illustrated in Figure 4.2. Note that the inter-quartile range (IQR = 25.75) represents the spread of the distribution of the paired difference scores.

Response	Mean Response	Standard Deviation	1st Quartile	3rd Quartile
During SPAD	78.59	20.47	71.50	95.00
In General	10.08	15.93	1.00	13.50
Difference	67.02	24.49	54.75	80.50

Table 4.2 Motion Sickness Scale Responses.

The second portion of the motion sickness scale consisted of a list of motion sickness symptoms in which the respondents rated the severity of the symptoms experienced both "During SPAD" and "In General." From these values the differences in severity experienced by each respondent both "During SPAD" and "In General" were

calculated. These paired differences were used to compute the mode responses and the number of subjects reporting an increase in severity for each of the symptoms. These values are summarized in Table 4.3. Note that the mode responses were greater during SPAD training for all of the symptoms except "retching or vomiting." Additionally, all the increases in symptom severity between the two conditions were statistically significant ($p < 0.05$).

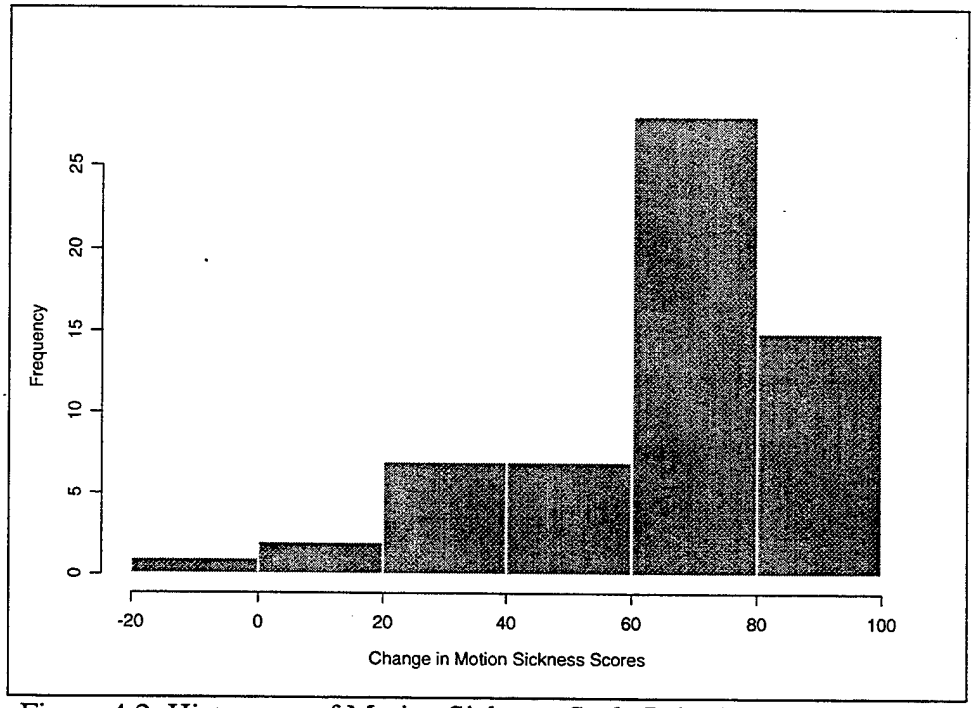

Figure 4.2 Histogram of Motion Sickness Scale Paired Difference Scores.

Symptoms	Mode response During SPAD	Mode response In General	Percent of respondents reporting an increase	Z-value	p-value
Nausea	3	0	97%	9.60	0.00
Salivation	2	0	93%	9.23	0.00
Cold Sweating	3	0	88%	8.73	0.00
Pallor	2	0	88%	8.56	0.00
Drowsiness	3	0	87%	7.43	0.00
Headache	3	0	87%	7.54	0.00
Flushing/ Warmth	2	0	83%	8.13	0.00
Dizziness	3	0	87%	8.09	0.00
Stomach Awareness	1	0	75%	8.20	0.00
Retching or Vomiting	0	0	45%	5.85	0.00

Table 4.3 Motion Sickness Symptom Responses.

3. Mood Scale

The mood scale requested the respondents to rate their feelings toward 49 different moods both "During SPAD" and "In General." After a literature review, the author selected 16 of the 49 moods that appeared to be symptomatic of Sopite Syndrome. This reduction in moods was verified utilizing the empirical cumulative distribution function (cdf) technique. Through this technique, the cdf's were calculated for all of the 49 moods and then the respective values were examined to see which moods had the largest increase in their cdf's to the right of zero. This corresponded to the greatest increase between "During SPAD" and "In General." Some examples of the empirical cdf values are displayed in Table 4.4.

Moods	-3	-2	-1	0	1	2	3
Active	0.00	0.00	0.00	0.22	0.35	0.65	1.00
Tired	0.00	0.00	0.03	0.25	0.43	0.67	1.00
Calm	0.00	0.027	0.07	0.53	0.77	0.93	1.00
Placid	0.03	0.08	0.23	0.65	0.80	0.95	1.00

Table 4.4 Empirical Cumulative Distribution Functions for Selected Moods.

As depicted in Table 4.4, the moods "active" and "tired" only have 22% and 25% of the cumulative distribution accounted for to the left of and including zero, which indicates that the majority of the paired difference scores have positive increases. In contrast, the moods "calm" and "placid" have 53% and 65% of the cumulative distribution already accounted for to the left of and including zero, which indicates that a majority of the paired difference scores possess decreasing severity or no change at all. The resulting moods with the largest increases in their cdf's to the right of zero corresponded to the same 16 moods chosen by the author after the literature review. These 16 moods and their corresponding mode responses are presented in Table 4.5. Note that some of the moods had increases in responses, whereas others had decreases. This was due to the design of the rating scale. The rating scale did not take into account that some moods such as "sleepy," "grouchy," and "tired" are measured in the reverse order of such moods as "peppy," "energetic," and "lively." The moods that are measured in reverse order (a decrease vice increase in severity) are annotated with an asterisk in Table 4.5. Once the 16 moods were selected, the total change across all moods between the two conditions was calculated for each of the respondents. These cumulative paired differences for each respondent were then used to compute the mean, standard deviation, and first and third quartiles. The resulting mean was 22.63, the standard deviation was

12.06, and the first and third quartiles were 14 and 34 respectively. The distribution of the changes in the mood scores between the two conditions, as reported by each of the respondents, is shown in Figure 4.3. This figure also displays the spread of the distribution represented by the inter-quartile range (IQR = 20).

Moods	**Mode response During SPAD**	**Mode response In General**	**Percent of respondents reporting increase or decrease (*)**
Peppy	4	2	73% (*)
Sleepy	1	4	73%
Grouchy	2	4	48%
Energetic	4	2	77% (*)
Tired	1	4	75%
Vigorous	4	2	85% (*)
Drowsy	1	4	80%
Lively	4	2	83% (*)
Wide-awake	4	1	73% (*)
Full-of-pep	4	2	78% (*)
Quiet	1	2	52%
Concentrating	4	2	58% (*)
Sluggish	1	4	82%
Wakeful	4	2	65% (*)
Active	4	1	78% (*)
Tense	2	4	45%

Table 4.5 Mood Scale Responses.

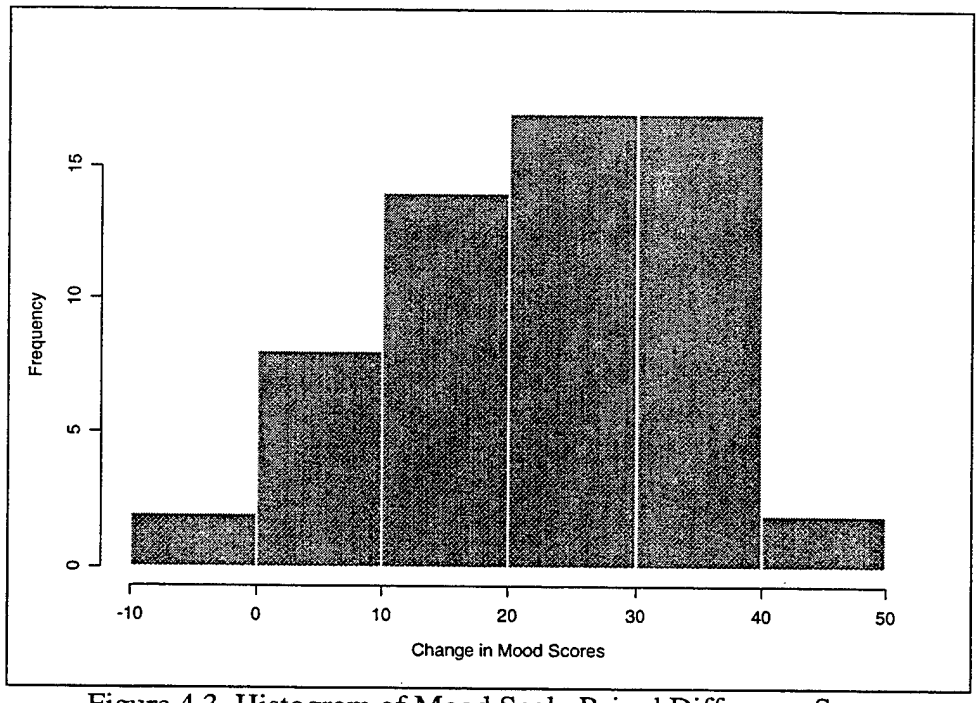

Figure 4.3 Histogram of Mood Scale Paired Difference Scores.

4. Drowsiness during SPAD Training Scale

The first portion of the drowsiness scale consisted of a visual analog scale in which the respondents were requested to estimate their sleepiness both "During SPAD" and "In General." These responses were utilized to calculate the paired differences in sleepiness scores reported by each of the respondents during the two conditions. These values were then utilized to compute the mean, standard deviation, and the first and third quartiles of the responses. The results are summarized in Table 4.6. Note that the mean response for the amount of sleepiness experienced "During SPAD" was much greater than that of "In General." The actual number of respondents who reported an increase in the amount of sleepiness experienced during SPAD training was 52 out of 60 (87%). With an alpha level of 0.05, the increase in sleepiness was statistically significant

($Z = 6.26$, $p = 0.00$). The changes in sleepiness scores between the two conditions, as reported by each of the respondents, and the spread of the distribution represented by the inter-quartile range (IQR = 44.5) are illustrated in Figure 4.4.

Response	Mean Response	Standard Deviation	1st Quartile	3rd Quartile
During SPAD	66.10	26.65	53.50	84.00
In General	22.35	19.74	6.00	31.00
Difference	42.65	31.65	24.75	69.25

Table 4.6 Drowsiness during SPAD Training Scale Responses.

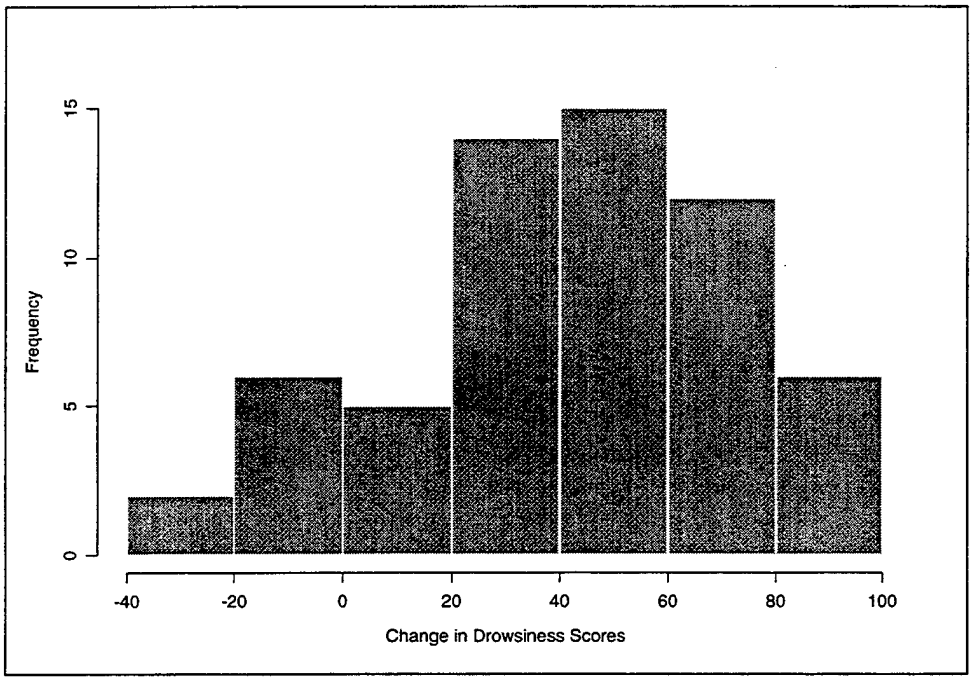

Figure 4.4 Histogram of Drowsiness Scale Paired Difference Scores.

The second portion of the drowsiness scale consisted of two rating scales in which the respondents rated their levels of alertness for both conditions, "During SPAD" and "In General." These respective values were utilized to calculate the paired differences in alertness between the two conditions for each of the respondents. The mode responses for "During SPAD" and "In General" are depicted in Table 4.7. Note that the mode

response for "During SPAD" was greater than the mode response for "In General." The actual number of respondents who reported a decrease in alertness during SPAD training was 54 out of 60 (90%). With an alpha level of 0.05, the increase in sleepiness rating was statistically significantly ($Z = 6.69$, $p = 0.00$). The changes in scores between the two conditions for each of the respondents are shown in Figure 4.5.

Response	Mode Response
During SPAD	6
In General	1
Difference	4

Table 4.7 Sleepiness Rating Scale Responses.

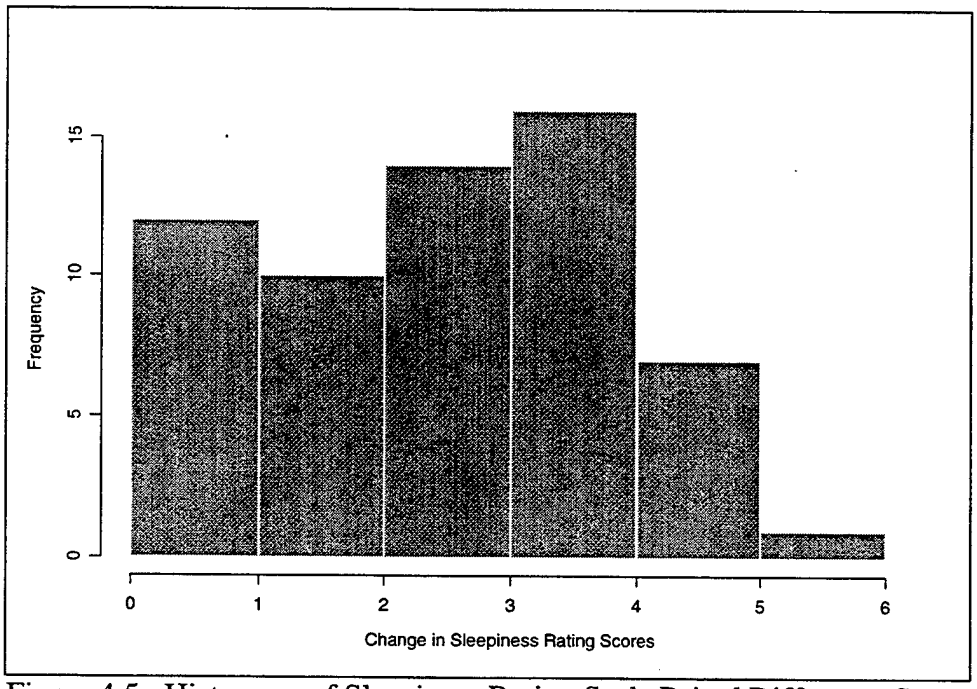

Figure 4.5. Histogram of Sleepiness Rating Scale Paired Difference Scores.

5. Fatigue Scale

The fatigue scale responses for each statement were recorded for both "During SPAD" and "In General." The number of affirmative responses in each category was then tabulated for each respondent. These totals were utilized to calculate the paired

differences between the total number of responses provided both "During SPAD" and "In General." The mean, standard deviation, and the first and third quartiles for these paired differences are summarized in Table 4.8. Note that there were more fatigue disturbances reported "During SPAD" than "In General." The actual number of respondents who reported an increase in fatigue disturbances during SPAD training was 42 out of 60 (70%). With an alpha level of 0.05, the increase in fatigue disturbances was statistically significant ($Z = 5.67$, $p = 0.00$). The changes in fatigue scores between the two conditions, as reported by each of the respondents, and the spread of the distribution represented by the inter-quartile range ($IQR = 4$) are illustrated in Figure 4.6.

Response	Mean Number of Responses	Standard Deviation	1st Quartile	3rd Quartile
During SPAD	2.70	2.04	1	4
In General	0.53	1.19	0	1
Difference	2.17	2.28	0	4

Table 4.8 Fatigue Scale Responses.

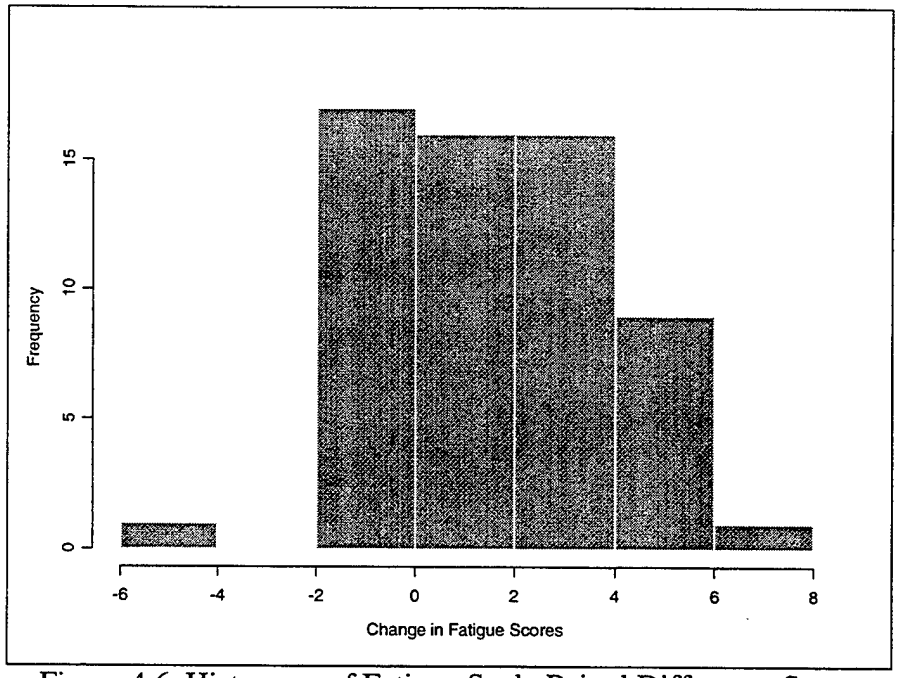

Figure 4.6 Histogram of Fatigue Scale Paired Difference Scores.

B. CORRELATIONS BETWEEN SCALES

The Spearman's rho was utilized to test whether a relationship between each of the scales existed. The values for the Spearman's rho can range in value from +1 to –1, with the positive and negative one being interpreted as a perfect correlation. According to Fink (1995), a conservative rule of thumb for correlation values is as follows: a value from 0 to ±0.25 indicates that there is little to no relationship, a value from ±0.26 to ±0.50 indicates a fair degree of relationship, and a value from ±0.51 to ±0.75 indicates a moderate to good relationship. The author goes on to explain that for some social science disciplines, a correlation of ±0.26 to ±0.50 is considered quite high. The resulting values for each of the possible combinations of scales are summarized in Table 4.10. Testing was performed with an alpha level of 0.05. Because 15 individual tests were conducted, one for each combination of scales, the significance level was reduced to 0.003 (0.05/15).

With an alpha level of 0.003, no combination with motion sickness was statistically significant under the null hypothesis that the correlation between each respective pair of scales is zero. As shown in Table 4.9, for those combinations that were statistically significant, the Spearman's rho values ranged from 0.36 to 0.64, which indicates a high correlation for this social science discipline.

Correlation	Spearman's rho	p-value
Drowsiness/Sleepiness Rating	0.61	0.00
Drowsiness/Fatigue	0.47	0.00
Drowsiness/Sleep	0.47	0.00
Drowsiness/Motion Sickness	0.26	0.05
Drowsiness/Mood	0.51	0.00
Sleepiness Rating/Fatigue	0.51	0.00
Sleepiness Rating/Sleep	0.54	0.00
Sleepiness Rating/Motion Sickness	0.18	0.17
Sleepiness Rating/Mood	0.49	0.00
Fatigue/Sleep	0.64	0.00
Fatigue/Motion Sickness	0.25	0.06
Fatigue/Mood	0.54	0.00
Sleep/Motion Sickness	0.32	0.01
Sleep/Mood	0.55	0.00
Motion Sickness/Mood	0.36	0.01

Table 4.9 Measure of Relationships between Scales.

C. GROUP COMPOSITION

The method utilized to break the subjects into respective groups based upon the literature was as follows: everyone who had positive increases in sleep, fatigue, drowsiness, and sleepiness rating scales were classified as exhibiting symptoms of Sopite Syndrome. Those who did not have positive increase in all of the respective categories

were classified as not exhibiting symptoms of Sopite Syndrome. The results of the classification are shown in Table 4.10.

Groups	Total Number or Subjects	Percentage of Subjects
Sopite Candidates	27	45%
Non-Sopite Candidates	33	55%

Table 4.10 Sopite/Non-Sopite Classification Groups.

The Sopite and Non-Sopite classification groups were then further subdivided into those candidates who were successfully returned to flight status and those who were not. These new classifications are displayed in Table 4.11. To help illustrate the group compositions, a bar chart is provided in Figure 4.7. The two-sided Fisher test was utilized to test whether a relationship exists between Sopite/Non-Sopite classification and flight status. Hence, the null hypothesis (H_o) to be tested was defined as follows: Sopite/Non-Sopite classification and flight status are statistically independent. The Fisher test yielded a p-value = 0.22, thus with an alpha value of 0.05, the null hypothesis can not be rejected. Thus, there is not enough evidence to indicate a relationship exists between Sopite/Non-Sopite classification and flight status.

Groups	Returned to Flight Status	Not Returned to Flight Status	Total
Sopite Candidates	19	8	27
Non-Sopite Candidates	28	5	33
Total	47	13	60

Table 4.11 Contingency Table of Classification Groups.

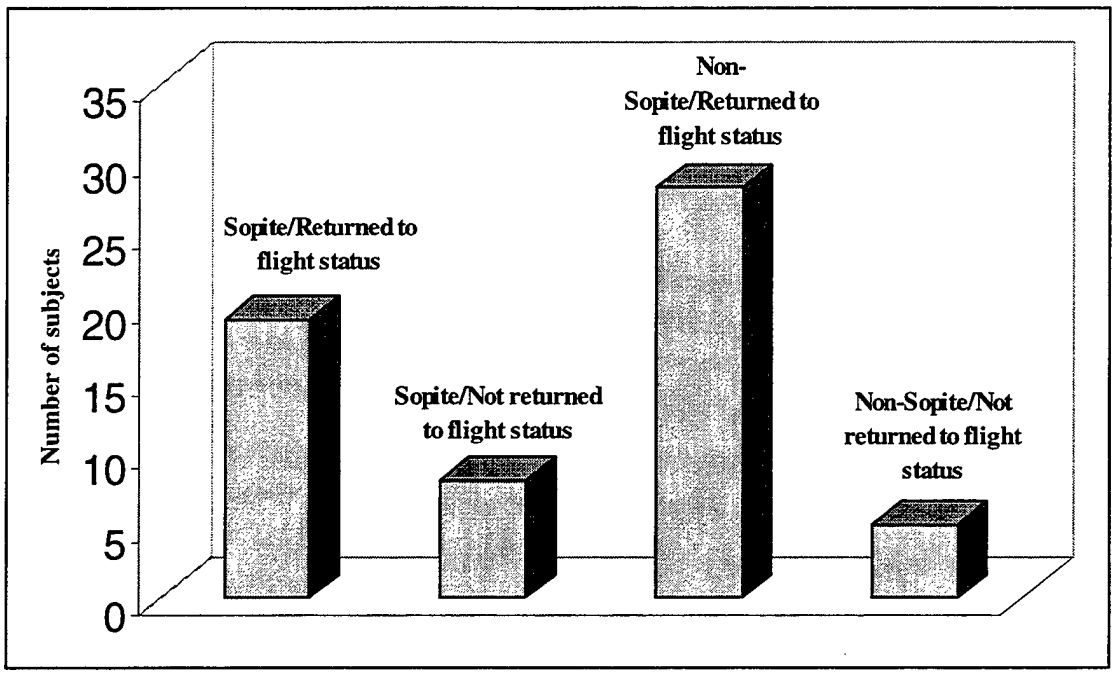

Figure 4.7 Bar Chart of Classification Groups.

Further evidence to substantiate the methodology for the classification of those respondents exhibiting characteristics of Sopite Syndrome was obtained through a permutation test. The permutation test utilized data from the mood scale. The rationale for this choice was two-fold: 1) mood changes are defined in the literature as being characteristic of Sopite Syndrome and 2) this specific data was not utilized in the selection of the Sopite Syndrome candidates. Hence, the null hypothesis (H_o) was defined as follows: the Sopite candidates' level of mood changes is the same as that of the rest of the sample population. If the null hypothesis is true, the sum of the 27 scores for the Sopite candidates should be comparable to the sum of any other random set of 27 scores from the sample population in the size of mood changes experienced. In order to test the null hypothesis a function was written in S-PLUS to generate the sum of 27

numbers chosen randomly from the original 60 mood difference scores (a copy of the S-PLUS code is included in Appendix A).

Twenty-seven values were utilized to correspond to the number of Sopite candidates identified. The sums that were generated were compared to the sum of the mood difference scores of those respondents identified as exhibiting symptoms of Sopite Syndrome. A running tally was kept as to the number of times that the generated sum exceeded the sum of the Sopite candidates' scores. The results of the permutation test showed there was a statistically significant ($p < 0.05$) difference between the average size of mood changes experienced by the Sopite Syndrome candidates from that of the rest of the population. Thus, the null hypothesis that there is no difference in mood changes between those respondents exhibiting symptoms of Sopite Syndrome and the sample population is rejected. This test therefore supports the methodology used in the selection of Sopite Syndrome candidates.

D. DESCRIPTIVE STATISTICS FOR GROUP CLASSIFICATIONS

From the original group of 60 former SPAD participants, 27 of them were classified as exhibiting symptoms characteristic of Sopite Syndrome while the remaining 33 of them were classified as not exhibiting symptoms characteristic of Sopite Syndrome. The paired difference scores between "During SPAD" and "In General" for both of the respective groups were utilized to compute the mean, standard deviation, and the first and third quartiles. Table 4.12 summarizes the values for Sopite/Non-Sopite groups. The degree in which the Sopite group exhibited increased levels of severity in each of the scales was much greater than that experienced by the Non-Sopite group. This observation helps to support the idea that differences between the two groups with

respect to the different scales do exist. To help illustrate the differences between the two groups, a box plot for each of the scales is provided in Figure 4.8.

Survey Scales		Mean	Standard Deviation	1st Quartile	3rd Quartile
Sleep	Sopite	4.07	2.95	1.5	6.5
	Non-Sopite	-1.33	2.23	-2.0	0.0
Motion Sickness	Sopite	75.11	17.23	67.5	87.5
	Non-Sopite	60.73	27.73	36.0	79.0
Mood	Sopite	29.85	8.17	25.5	35.0
	Non-Sopite	16.73	11.58	9.0	24.0
Drowsiness	Sopite	59.33	21.54	40.5	75.0
	Non-Sopite	29.00	32.29	3.0	53.0
Sleepiness Rating	Sopite	3.70	1.14	3.0	4.0
	Non-Sopite	2.21	1.52	1.0	3.0
Fatigue	Sopite	3.59	1.62	2.5	4.5
	Non-Sopite	1.00	2.08	0.0	2.0

Table 4.12 Descriptive Statistics for Sopite/Non-Sopite Groups.

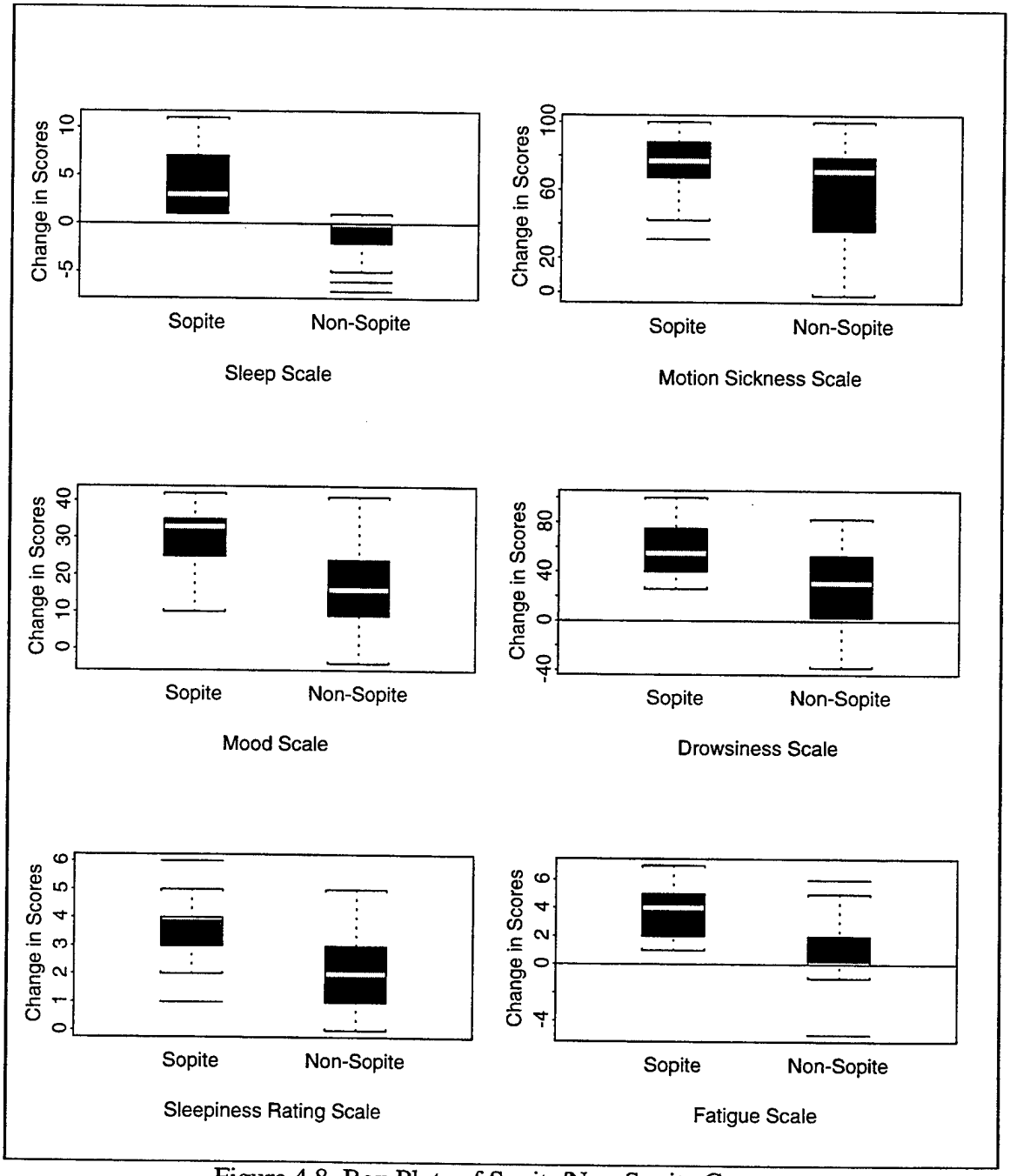

Figure 4.8 Box Plots of Sopite/Non-Sopite Groups.

The paired differences between "During SPAD" and "In General" for the four categories (Sopite candidate and returned to flight status; Sopite candidate and not returned to flight status; Non-Sopite candidate and returned to flight status; and Non-Sopite candidate and not returned to flight status) were utilized to compute the mean values. These values are displayed in Table 4.13. The degree of severity between those participants who were not returned to flight status and those who were returned to flight status for both the Sopite and Non-Sopite groups was larger in each of the respective cases. This illustrates that those student aviators not returned to flight status experienced more severe symptoms.

Survey Scale	S/RTN	S/NRTN	NS/RTN	NS/NRTN
Sleep	3.53	5.38	-1.36	-1.20
Motion Sickness	75.32	74.63	59.46	67.80
Mood	29.00	31.88	15.54	23.40
Drowsiness	57.84	62.88	27.82	35.60
Sleepiness Rating	3.58	4.00	2.07	3.00
Fatigue	3.05	4.88	0.61	3.20

Table 4.13 Mean Values for Classification Groups.

E. STATISTICAL INFERENCE BETWEEN GROUPS

The Mann-Whitney test was utilized to perform simultaneous tests for whether the differences between the two groups, Sopite and Non-Sopite, with respect to the various scales (six in all) are statistically significant. This nonparametric test is a procedure to test whether the two groups came from the same distribution. Hence, the null hypothesis (H_o) was defined as follows: the two groups are from the same distribution. If the null hypothesis is true, the p-value for the respective scales should be

greater than an alpha level of 0.008 (0.05/6). The resulting Z and p-values from the Mann-Whitney test are summarized in Table 4.14.

Survey Scales	Z value	Mann-Whitney Test p-value
Sleep	6.41	0.00
Motion Sickness	1.96	0.05
Mood	4.10	0.00
Drowsiness	3.60	0.00
Sleepiness Rating	3.71	0.00
Fatigue	4.67	0.00

Table 4.14 Significance Values for Independent Two-Sample Case.

As indicated by the values displayed in Table 4.14, the difference between the groups was statistically significant for each of the scales, excluding motion sickness. Therefore, the null hypothesis was rejected for each of the scales, excluding motion sickness. From this we may conclude that the two groups were not drawn from the same distribution.

F. SLEEP/FATIGUE QUESTIONS

The sleep scale consisted of a series of 38 questions pertaining to various sleep disturbances (these questions are included in Appendix B). Of these 38 questions, 15 were discarded because less than 5% of the sample population provided an affirmative response to these questions. The discarded questions therefore did not allow for any differentiation between groups. The summary of the response percentages for the remaining questions is provided in Table 4.15. Among respondents that were returned to flight status, there were nine specific questions (numbers 1, 5, 6, 9, 15, 19, 22, 26, and 38) that had larger response percentages (at least 15% larger) for Sopite candidates than

those of Non-Sopite candidates. Among respondents that were not returned to flight status, there were eight specific questions (numbers 1, 5, 6, 9, 15, 19, 22, and 38) that had percentages larger in the same way. Each of these same eight questions appear in the previous nine. This implies that these eight questions may be indicators for successfully predicting Sopite candidates with regard to sleep disturbances.

Question	Sopite Candidate & Returned to Flight Status (n=19)	Non-Sopite Candidate & Returned to Flight Status (n=28)	Sopite Candidate & Not Returned to Flight Status (n=8)	Non-Sopite Candidate & Not Returned to Flight Status (n=5)
1	42%	18%	38%	20%
4	26%	21%	38%	60%
5	84%	50%	100%	80%
6	26%	4%	63%	0%
9	84%	32%	88%	60%
10	11%	14%	13%	40%
11	5%	25%	0%	0%
12	16%	25%	13%	0%
15	47%	25%	38%	20%
16	16%	11%	0%	20%
17	26%	29%	13%	0%
19	53%	14%	63%	20%
22	42%	4%	63%	40%
23	21%	25%	13%	20%
24	5%	7%	13%	20%
25	26%	46%	25%	20%
26	21%	0%	38%	40%
28	11%	7%	13%	0%
33	32%	29%	63%	80%
34	26%	21%	38%	40%
36	5%	0%	13%	0%
37	0%	7%	25%	20%
38	79%	36%	63%	40%

Table 4.15 Percentage of Respondents Within Each Group Who Reported Affirmative Responses for the Sleep Scale.

The fatigue scale consisted of ten questions (the questions are provided in Appendix C). Of these ten questions, three were discarded because less than 2% of the sample population provided an affirmative response to these questions. These discarded questions therefore did not allow for any differentiation between groups. The summary of the response percentages for the remaining questions is provided in Table 4.16.

Question	Sopite Candidate & Returned to Flight Status (n=19)	Non-Sopite Candidate & Returned to Flight Status (n=28)	Sopite Candidate & Not Returned to Flight Status (n=8)	Non-Sopite Candidate & Not Returned to Flight Status (n=5)
1	84%	36%	100%	100%
2	42%	21%	63%	60%
3	84%	32%	88%	40%
6	5%	4%	38%	40%
8	47%	14%	75%	80%
9	42%	18%	63%	20%
10	16%	18%	75%	20%

Table 4.16 Percentage of Respondents Within Each Group Who Reported Affirmative Responses for the Fatigue Scale.

Among those respondents who were returned to flight status, there were five specific questions (numbers 1, 2, 3, 8, and 9) that had larger response percentages (greater than 15%) for Sopite candidates than those of Non-Sopite candidates, while among the other, three questions (numbers 3, 9, and 10) had response percentages larger in this way. Note that questions three and nine appear for both groups. This implies that these two questions may be indicators for successfully predicting Sopite candidates with regard to fatigue disturbances.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The purpose of this study was to determine if personnel diagnosed with motion sickness exhibited symptoms characteristic of Sopite Syndrome while participating in the SPAD rehabilitation program. Exploratory data analysis and non-parametric techniques were utilized in the research into symptoms consistent with Sopite Syndrome included. Such procedures are frequently used by the behavioral scientist.

The thesis investigated and sought to answer six research questions. Specifically addressed is the effect Sopite Syndrome may have on the successful completion of treatment and ultimate return to flight status of a SPAD participant. The answers to the six research questions are presented as follows:

1. Descriptive statistics were generated to illustrate the central tendencies and dispersions for each survey scale. Individual scale results can be found in Chapter IV. The Wilcoxon Signed-Rank Test was applied to each scale to determine whether the paired differences between the conditions, "During SPAD" and "In General," were statistically significant. Using an alpha level set at 0.05, the paired differences between the two conditions were statistically significant for all scales. The actual percentages of respondents who reported increases between the two conditions were 53% for the sleep scale, 98% for the motion sickness scale, 45% to 85% for each of the 16 moods, 87% for the drowsiness scale, 90% for the sleepiness rating scale, and 70% for the fatigue scale.

2. In analyzing the empirical cdf's, the original 49 moods were reduced to a total of 16. The final 16 moods identified as those which are most prevalent in aviation students who were referred to the SPAD rehabilitation program are as follows: peppy,

sleepy, grouchy, energetic, tired, vigorous, drowsy, lively, wide-awake, full-of-pep, quiet, concentrating, sluggish, wakeful, active, and tense.

3. The Spearman rho rank correlation statistic was used to measure the relations between each possible combination of scales. The correlation values ranged from 0.18 to 0.64 and are listed in Table 4.9. All combinations that did not include the motion sickness scale were statistically significant. The fact that motion sickness was not statistically significant was expected, since the sample population surveyed had been previously diagnosed as susceptible to motion sickness. For those relationships that were statistically significant, the correlation values ranged from 0.36 to 0.64, which indicates a high correlation for behavioral data.

4. From the original sample population of 60 former SPAD participants, 27 (45%) of them exhibited symptoms characteristic of Sopite Syndrome. Of these 27 individuals, 19 (70%) of them were returned to flight status. Furthermore, of the 33 remaining SPAD participants not classified as exhibiting symptoms characteristic of Sopite Syndrome, 28 (85%) were returned to flight status. The Fisher Exact Test was applied to determine whether a relationship existed between Sopite/Non-Sopite classification and flight status. Using an alpha level set at 0.05, there was not enough evidence to indicate that a relationship existed. Thus, the apparent existence of Sopite Syndrome does not alone affect the candidates' successful completion of treatment and ultimate return to flight status.

5. Initial compositions of Sopite and Non-Sopite groups were determined through literature with focus on primary symptom requirements and constraints. Selection criteria were then validated using a permutation test with significant results (alpha = 0.05). The

Mann-Whitney test was then utilized to determine the statistical significance between the groups. With an alpha level set at 0.05, the differences between the two groups for each of the respective survey scales were statistically significant. Such results enhance the credibility of the claim that Sopite Syndrome exists.

6. With regards to the sleep scale, there were eight specific questions that may be indicators for successfully predicting Sopite Syndrome candidates. These are questions 1, 5, 6, 9, 15, 19, 22, and 38, which are provided in Appendix B. With regards to the fatigue scale, there were two specific questions that may be indicators for successfully predicting Sopite candidates. These questions, numbers 3 and 9, are provided in Appendix C. Such questions are highly correlated to the symptomology of Sopite Syndrome as defined in the literature.

B. RECOMMENDATIONS

Since symptoms consistent with Sopite Syndrome were reported by 45% of the SPAD participants, it is recommended that the SPAD survey be administered to other aviation populations to assess its existence in the fleet. In the meantime, aviation squadrons should be educated on the symptoms characteristic of Sopite Syndrome and the potential dangers they may pose to aviators during flight. Due to the result that 19 out of 27 (70%) of the former SPAD participants who exhibited symptoms characteristic of Sopite Syndrome successfully completed treatment and were returned to flight training, it is recommended that a separate treatment program be developed for Sopite Syndrome.

Recently, the Navy has begun testing in the Human Disorientation Device (HDD) at NAMRL to further investigate the existence of Sopite Syndrome. The research team is currently gathering information on the physiological variables that may contribute to the

apparent existence of Sopite Syndrome. It is recommended that the SPAD survey be administered to the experiments' participants and then matched against the physiological variables from the experiment. The data that is gathered from these experiments may be used to determine the actual causes of Sopite Syndrome and to determine if there are any methods by which the effects of Sopite Syndrome can be reduced or alleviated.

APPENDIX A. S-PLUS CODE FOR PERMUTATION TEST

```
> boot
function(n, a, tot)
{
#
#  Function name:  boot
#
#  This function will permutate 27 random numbers from the
#  sample vector (a) provided. It will then compare the sum
#  of these 27 numbers to the sum provided (tot).  The
#  permutation will be performed n times and a tally of the
#  number of sums generated that are larger than the sum
#  provided will be taken.
#
#
#  parameters:    n = the number of iterations to perform
#                 a = the vector of scores to choose the 27
#                     random numbers from
#               tot = the total value of the Sopite scores
#                     in the vector a
#
        total <- 0
        for(i in 1:n) {
        perm <- sample(a)
        summ <- sum(perm[1:27])
        if(summ > tot)
            total <- total + 1
        }
        total
}
```

APPENDIX B. SLEEP SCALE QUESTIONS

1. I have been told that I snore.
2. I have been told that I hold my breath while I sleep.
3. I have high blood pressure.
4. My friends/family say I'm often grumpy and irritable.
5. I wish I had more energy.
6. I get morning headaches.
7. I often wake up grasping for breath.
8. I am overweight.
9. I often feel sleepy & struggle to remain alert during the day.
10. I frequently wake with a dry mouth.
11. I have difficulty falling asleep.
12. Thoughts race through my mind & prevent me from getting to sleep.
13. I anticipate a problem with sleep several times a week.
14. I often wake up and have trouble going back to sleep.
15. I worry about things and have trouble relaxing.
16. I wake up earlier in the morning than I would like to.
17. I lie awake for half an hour or more before I fall asleep.
18. I often feel sad or depressed because I can't sleep.
19. I have trouble concentrating at work or school.
20. When I am angry or surprised, I feel like my muscles are going limp.
21. I have fallen asleep while driving.
22. I often feel like I am in a daze.

23. I have experienced vivid dreamlike scenes upon falling asleep or awakening.

24. I have fallen asleep in social settings such as movies or at a party.

25. I have vivid dreams soon after falling asleep or during naps.

26. I have "sleep attacks" during the day where I fall asleep no matter how hard I try to stay awake.

27. I have episodes of feeling paralyzed during my sleep.

28. I wake up at night with an acid/sour taste in my mouth.

29. I wake up at night coughing or wheezing

30. I have frequent sore throats.

31. I have heartburn at night.

32. During the night I suddenly wake up feeling like I am choking.

33. I have noticed (or others hav nmented) that parts of my body jerk during sleep.

34. I have been told that I kick and jerk during sleep.

35. When trying to go to sleep, I experience an aching or crawling sensation in my legs.

36. I have experienced leg pains and cramps at night.

37. Sometimes I can't keep my legs still at night, I just have to move them to feel comfortable.

38. Even though I slept during the night, I feel sleepy during the day.

APPENDIX C. FATIGUE SCALE QUESTIONS

1. I tend to feel persistent, unexplained or recurrent fatigue that does not seem to depend upon my level of rest or exertion.
2. I tend to feel an impairment in my short term memory or concentration.
3. I tend to feel a reduction from my previous levels of occupational, educational, social or personal activities.
4. I tend to get sore throats.
5. I tend to feel tender lymph nodes in my neck, armpits, or groin.
6. I tend to feel muscle pain.
7. I tend to feel multi-joint pain without joint swelling or redness.
8. I tend to feel headaches of a new type, pattern or severity.
9. I tend to have unrefreshing sleep.
10. I tend to feel post exertional "malaise" (discomfort or uneasiness) lasting for more than 24 hours.

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